Voluntary Process for Evaluating Deicer Application Rate Achievement

Purpose:

The purpose of this **voluntary process recommendation** is to provide a continual improvement process for winter maintenance operations that is focused on application rates and Levels of Service (LOS). **In summary, the process involves selecting a target application rate(s), determining the quantity of deicer used, evaluating whether or not LOS were achieved, and evaluating whether or not the target application rate(s) was/were achieved. The result of the evaluations can highlight challenges and/or areas for improvement.** Because of the many factors that complicate the implementation of this approach, this process is recommended as a voluntary process that is to be implemented at scales that make sense for the operation (i.e., all treatments may not be able to be evaluated).

Implementing specific application rates can be a challenge. Whether an operation is beginning to try a single application rate or is working towards varying application rates based on the weather, achieving the intended application rate(s) is a challenging pursuit. This document summarizes steps that can be taken to choose an application rate(s), measure deicer use, establish the winter storm severity, evaluate if LOS were achieved (and if not, why), and evaluate whether or not the target application rate was achieved (and if not, why). Whenever the answer is "no" for the two evaluation steps, identifying the reasons why will highlight areas for improvement or provide insight into areas where application rates may need to be adjusted. Depending on the scale of the operation, conducting this process for all surfaces managed may be impractical. In such cases, it is recommended that operations exercise this process on one to a few treatments (see "treatment" definition below, "Process Details" 1.a) to spot check the application rate and LOS achievement.

Application Rates:

Because of the variety of application rate guidelines that already exist, stakeholders involved in the development of the Salt Management Strategy (SaMS) recommended that the SaMS not include specific application rate recommendations. While many operations already have guidelines for application rates, some may not. For operations that would like an application rate resource to use as a guide, selected existing application rates for transportation operations and for property management operations (e.g., parking lots, sidewalks, etc.) are provided in Appendix A and Appendix B of this document, respectively. There are also plenty of resources on the internet.

Process:

Process Summary:

The basic process involves selecting a target application rate(s), determining the quantity of deicer used, establishing storm severity, evaluating whether or not LOS were achieved, and evaluating whether or not the target application rate(s) was/were achieved. The evaluations will identify challenges and/or areas for improvement.

For many operations, implementing the recommendations below for the entire operation is not practical. In cases where the size and/or complexity (e.g., staff and contract operators) of the operation complicate the broad-scale use of these processes, it is recommended that the operation implement the process below as random spot checks at a proportion of the total operation that is practical and appropriate.

Process Details:

1. Choosing a **target application rate** for a "treatment":
    a. Note – what constitutes a "treatment" varies by the operation type and is defined below.
        i. For transportation operations, a "treatment" is defined here as the application of deicer over a single route.
        ii. For property management operations, a "treatment" is defined here as the one-time application of deicer over all surfaces treated at a property (i.e., reapplications are separate "treatments").
    b. Some operations may have application rate guidelines already in place. In these cases, follow the guidelines to choose the appropriate application rate(s).
    c. Where operations do not have application rate guidelines in place, use the information in Appendix A or Appendix B. If this is the first time an operation has used a specific application rate, it is recommended to start on the high end of the chart, regardless of the weather condition. If the operation achieves these higher application rates and the defined LOS ("Process Details" steps 4 and 5 = "yes"), the operation can experiment with lower/more weather-specific application rates.
2. Determine the **quantity of deicer used** for each treatment:
    a. For operations with automated deicer measuring equipment, a best practice is to periodically compare the measurements to the estimates calculated using steps 2.b and 2.c below.
    b. For transportation operations, the amount of deicer applied can be estimated two different ways depending on whether or not the operation has a scale and/or can use the scale effectively during the storm.
        i. Measuring Salt Weight: For operations where a **loader scale is available**, the amount of deicer applied can be estimated by measuring the weight of the truck after it has been loaded (T_L), and then measuring the weight of the truck after it has returned from its route (T_R). The units for weight should be in pounds (lbs). With these values the amount of deicer applied during a single treatment (D_A) can be estimated by:

$$D_A = T_L - T_R$$

        ii. Estimating Salt Weight: For operations where a **loader scale is not available** (i.e., the operation does not have one or it is not possible to use effectively during an event), a rough estimate of the weight of deicer loaded (D_L) can be estimated two ways based on the bucket used to load the deicer. The units for weight should be in pounds (lbs). With the estimate of deicer loaded (D_L) known, step 2.b.iii below explains how to estimate the amount of deicer applied during a single treatment (D_A). Depending on the material, the volume to weight conversion ($D_{V\text{-}W}$) may be known (e.g., from the provider), or it may have to be measured if a scale is available (see 2.b.ii.2 below):
            1. If the volume to weight conversion for the deicer ($D_{V\text{-}W}$) is known and the loading equipment's bucket volume (B_V) is known, the deicer weight of a full loader's bucket (B_W) can be estimated. This estimate can be calculated by:

$$B_W = B_V * D_{V\text{-}W}$$

            2. If the deicer weight for a full loader's bucket (B_W) is unknown and a scale is available, then the weight for a full loader's bucket can be estimated during periods when there is no storm activity. This calculation involves weighing an empty truck before it has been loaded (T_E) and then weighing the same truck after one bucket has been loaded into the truck (T_L). With that information the weight for a full loader's bucket (B_W) can be estimated by:

$$B_W = T_L - T_E$$

3. With the deicer weight of a full loader's bucket (B_W) known, then the estimate of deicer loaded (D_L) can be estimated by the number of buckets (B_N) loaded into the truck. If partially full buckets are loaded, then an eyeballed fraction of the bucket ($B_{fraction}$) can be multiplied by the deicer weight of a full loader's bucket (B_W) and added to the equation to estimate the deicer loaded (D_L).

$$D_L = (B_W * B_N) + (B_W * B_{fraction})$$

iii. With the estimate of deicer loaded (D_L) known, then the **amount of deicer applied** during a single treatment (D_A) can be estimated by estimating the remaining weight of deicer in the truck after the treatment (D_R) and subtracting that from the estimate of deicer loaded (D_L).

$$D_A = D_L - D_R$$

Methods for estimating the remaining weight of deicer in the truck after the treatment (D_R) will vary based on the availability of a scale.

1. Measuring Salt Used: If a **scale is available,** then the remaining weight of deicer in the truck after the treatment (D_R) can be estimated by measuring the weight of the truck when it has returned from its route (T_R), and measuring it again after it has unloaded the deicer and is empty (T_E). With these values the remaining weight of deicer in the truck after the treatment (D_R) can be estimated by:

$$D_R = T_R - T_E$$

2. Estimating Salt Used: If a **scale is not available**, then the remaining weight of deicer in the truck after the treatment (D_R) can be estimated visually assuming that the truck was fully loaded when the estimate of deicer loaded (D_L) was established. To do this, the remaining fraction of the truck bed that is full of deicer will have to be estimated visually ($T_{fraction}$). With this visual estimate, the remaining weight of deicer in the truck after the treatment (D_R) can be estimated by:

$$D_R = D_L * T_{fraction}$$

c. For **property management** operations, the amount of deicer can be estimated in a number of ways depending on the source of the deicer.

i. If the deicer is in **bags,** then the amount of deicer applied (D_A) can be estimated by the number of bags (B_N) used multiplied by their weight (B_W). The units for weight should be in pounds (lbs). If partial bags remain, a ballpark estimate can be made of the pounds of deicer used (PB_{est}).

$$D_A = B_N * B_W + PB_{est}$$

ii. If the deicer is in a **loose pile** (i.e., bulk salt), then the amount of deicer applied (D_A) can be estimated in a couple ways.

1. If the deicer is loaded into a spreader where a scale can measure the weight of the spreader, follow the process outlined in step 2.b.i above.
2. If the deicer is loaded into a spreader with a loading device (e.g., backhoe) and no scale is available, follow the process outlined in step 2.b.ii above.
3. If no scale is available, then estimates for the average deicer applied ($D_{A\text{-}avg}$) can be made by knowing the total weight of the deicer pile (P_{TW}) and the number of total treatments sourced from that pile (t_N). The units for weight should be in pounds (lbs).

$$D_{A\text{-}avg} = P_{TW}/t_N$$

3. Establish the **winter storm severity**

a. For all types of operations, the evaluations in steps 4 and 5 below will be more informed with information on the winter storm's characteristics. Therefore, operations should consider documenting six different factors to help establish the winter storm severity. The six factors that are helpful to track when documenting winter storm severity include storm type, in-storm road temperature, early storm

behavior, wind condition in storm, poststorm temperature, poststorm wind condition. With these six factors identified, the evaluations in step 4 and 5 will have information to provide context and the winter storm severity can be calculated based on the method described in Nixon & Qiu (2005).[1]

i. Storm type can be documented as follows:
    1. Heavy snow (>6 inches in 24 hours)
    2. Medium snow (2-6 inches)
    3. Light snow (<2 inches)
    4. Freezing rain

ii. In-storm road temperature can be documented as follows:
    1. Warm (>32^{o}F)
    2. Mid range (25-32^{o}F)
    3. Cold (<25^{o}F)

iii. Early storm behavior can be documented as follows:
    1. Starts as snow
    2. Starts as rain

iv. Wind condition in storm
    1. Light (<15 mph)
    2. Strong (>15 mph)

v. Poststorm temperature
    1. Same range as in storm
    2. Warming
    3. Cooling

vi. Poststorm wind condition
    1. Light (<15 mph)
    2. Strong (>15 mph)

4. **Evaluate if LOS** were **met** for the treatment:
    a. LOS may vary by the operation, the weather, the type of surface, or even the specific treatment. As a result, the methods for spot checking, auditing, or otherwise assessing the attainment of prescribed LOS will vary by operation. Some operations have mechanisms in place for assessing the achievement of LOS. However, if an operation does not have anything in place, the steps outlined in 4.b below can provide some examples.
    b. Where LOS are clearly prescribed for an operation, their attainment may be evaluated as follows:
        i. For transportation operations, the route can be evaluated after X amount of time from the treatment to document the road condition. In this case, X = the amount of time for the LOS to be met (typically taking into consideration the precipitation rate and total amount). The evaluator can spot check various areas on the route that may have different conditions (e.g., turns, hills, shady spots, etc.). The more information that is documented, the more detailed the evaluation can be.
        ii. For property management operations, a LOS evaluator can visit the property after X amount of time from the treatment to document the surface conditions. In this case, X = the amount of time for the LOS to be met (typically taking into consideration the precipitation rate and total amount). The evaluator can spot check various areas on the property that may have different conditions and that are covered by the contract (e.g., slopes, walkways, driving lanes, parking

[1] Nixon, W. A., & Qiu, L. (2005). Developing a Storm Severity Index. *Transportation Research Record*, *1911*(1), 143–148. https://doi.org/10.1177/0361198105191100114

spots, steps, shady areas, areas near snow piles, etc.). The more information documented, the more detailed the evaluation can be.

c. **When LOS** were **not met,** document the potential reasons for why the LOS were not met. Potential reasons may include:
    i. Weather changes/severity:
        1. Examples include changes in the precipitation totals/type/moisture content that was forecasted, changes in the temperature including refreeze, etc.
    ii. Route/Site conditions:
        1. Examples include left over accumulations/piles from previous events, changes in the route/site, obstructions, traffic/customer presence, etc.
    iii. Equipment/Product limitations:
        1. Examples include equipment failure, imprecise spreaders, deicer scatter, issues with deicing material, etc.
    iv. Application rate appropriateness:
        1. An example includes areas that require different (i.e., higher) application rates.
    v. Other
        1. An example may include operator error.

5. Evaluate if the chosen application rate(s) were achieved for the treatment:
    a. Automated Equipment**:** Some operations may have **automated deicer measuring equipment**. In these cases, the application rate(s) may be known at the time of treatment if spreaders have recently been calibrated. Therefore, if this rate is known with confidence (i.e., calibrated and verified), then the known application rate(s) can be compared to the application rate(s) chosen for the treatment in step 1 above.
    b. Estimating Application Rates: Where the actual rate of application has to be estimated (i.e., 5.a above does not apply), this can be accomplished by dividing the amount of deicer applied during a single treatment (D_A or $D_{A\text{-}avg}$, calculated in steps 2.b or 2.c above) by the total area of the surface treated (A_T) to get the average application rate for the treatment (AR_{avg}). This estimated average application can then be compared to the application rate(s) chosen for the treatment in step 1 above.
        i. For **transportation** operations, the total area of the surface treated (A_T) will be in units of lane miles.
        ii. For **property management** operations, the total area of the surface treated (A_T) will be in units of 1000 ft^2 or units of acres.

$$AR_{avg} = D_A/A_T$$

    c. Exceeding Target Application Rates: When the application rate(s) known in 5.a or calculated in 5.b exceed the application rate(s) chosen in step 1 above, document the potential reasons for why the application rate(s) were not met. Potential reasons may include:
        i. Weather changes/severity that necessitated more deicer application:
            1. Examples include changes in the precipitation totals/type/moisture content than was forecasted, changes in the temperature including refreeze, etc.
        ii. Route/Site conditions that necessitated more deicer application:
            1. Examples include left over accumulations/piles from previous events, changes in the route/site, shady areas, bridges, slopes, areas with drainage problems, or other areas that require different (i.e., higher) application rates.
        iii. Equipment/Product limitations:
            1. Examples include uncalibrated spreaders, non-variable spreaders, spreaders with limited settings, issues with deicing material, etc.

iv. Measurement of deicer use after reapplication during the same property visit:
    1. Examples include LOS not being met requiring additional application, owner/manager/constituents requested reapplication, etc.
v. Other
    1. Examples include the impact of traffic/customer obstructions, operator error, plowing operations were not adequate/successful, etc.

6. Identifying **areas for improvement**:
    a. If the **either** of the evaluations in steps 4 and 5 concluded that LOS or the chosen application rate(s) were not achieved, then the reasons identified in steps 4 and 5 can help to identify options for improvement. While not all reasons identified will provide immediate improvement options, many will highlight something that can be modified, invested in, or otherwise improved over time. Some reasons identified may highlight the challenges of winter maintenance, and these reasons (e.g., challenging areas for treatment) can play a role in adaptive and informed winter maintenance planning.
    b. If **both** of the evaluations in steps 4 and 5 concluded that LOS and the chosen application rate(s) were achieved, well done! In these cases, if the application rate(s) used for the treatment was identified in step 1.c, discuss the application rate's applicability to the conditions and consider whether a lower application rate may have been possible. If so, identify ways to refine operations and work towards more precise, variable, and temperature specific application rates.
    c. For steps 6.a and 6.b above, include documentation of the evaluation process and its conclusions in winter maintenance plans or planning processes.
    d. Finally, it is worth noting that most application rates apply to dry deicer. If LOS have been achieved (6.b above), there may be an opportunity to reduce application rates. As BMPs are implemented, including those that integrate liquids into operations, overall deicer use for a particular treatment (including anti-icing operations beforehand) may be decreased. All operations who achieve the condition outlined in 6.b are encouraged to experiment with deicer rates lower than those initially targeted in order to optimize application rate(s) for a treatment considering all BMPs being used. When experimenting, caution should be exercised to minimize any unintended impacts on LOS and public safety. In other words, efforts to optimize salt use should not compromise public safety.

Appendix A – Application Rates for Transportation Operations

Ohio Department of Transportation

Materials Application Guidelines

Conditions			Equipment	Pre-Treat	Light Snowfall*				Heavy Snowfall** w/Plowing				Freezing Rain			
Pavement Temperature Range, and Trend	Pavement surface at time of operation	Recommended Maintenance Action	Recommended Snow Removal Equipment	*** 23 % Solution of Salt Brine 23% (gal/mile)	Solid (#/mile)		*** ## Prewet solid (#/mile)	Comment #	Solid (#/mile)		*** ## Prewet solid (#/mile)	Comment #	Solid (#/mile)		*** ## Prewet solid (#/mile)	Comment #
Above 32°F Steady or rising	Dry, wet, slush, or light snow cover	Monitor Road and Weather Conditions	Front Plow Wing Plow Underbody Plow	20 - 40				1 2				1 2				
Above 32°F Below is imminent	Dry	Apply liquid or prewetted solid	Anti-Icing System or Salt Spreader and Pre-wetting Tanks	20 - 40			50 to 100				50 to 100	3				
	Wet, slush, or light snow cover	Apply liquid or prewetted solid	Anti-Icing System or Salt Spreader		50 to 100		50 to 100		200 to 300		100 to 200	3	300 to 400		200 to 300	
25°F to 32°F Remaining in range	Dry	Apply liquid or prewetted solid	Anti-Icing System or Salt Spreader and Pre-wetting Tanks	20 - 40			50 to 100				100 to 200	3				
	Wet, slush, or light snow cover	Apply liquid or prewetted solid	Anti-Icing System or Salt Spreader		100 to 200		50 to 100	5	300 to 400		300 to 400	3, 5	300 to 400		300 to 400	5
20°F to 25°F Remaining in range	Dry	Apply liquid or prewetted solid	Anti-Icing System or Salt Spreader and Pre-wetting Tanks	20 - 40			100 to 200									
	Wet, slush, or light snow cover	Apply liquid or prewetted solid	Anti-Icing System or Salt Spreader		200 to 300		100 to 200	5, 6	Max 400		Max 400	5, 6	Max 400		Max 400	5, 6
15°F to 20°F Remaining in range	Dry	Monitor Conditions						4				4				4
	Wet, slush, or light snow cover	Apply solid materials	Salt Spreader		300 to 400		300 to 400	5, 6	Max 400		Max 400	5, 6	Max 400		Max 400	5, 6
Below 15°F Steady of falling	Dry	Monitor Conditions						4				4				4
	Wet, slush, or light snow cover	Plow as needed Apply salt with calcium chloride	Front Plow Wing Plow Underbody Plow				200 to 300	5			Max 400	5	Max 400		Max 400	5

* less than 2 inch per hour ** 2 inch or more per hour

8 to 10 GALLONS of salt brine per TON is recommended for Pre-wet solid

1) Monitor temperatures and road pavement conditions for cold or icy spots. Treat problem areas as needed.
2) Treat icy spots at 100#/mile or 20 gal/mile, plow as needed.
3) Do not apply liquid to heavy snow accumulation or packed snow.
4) Do not apply chemicals and maintain dry pavement during windy conditions
5) A mixture of salt and abrasives is recommended or acceptable at these temperatures.
6) Calcium Chloride may be used in temperatures less than 25 degrees F

*** SEE ATTACHED FOR OTHER LIQUID ANTI/DE-ICER APPLICATION RATES

To access the original, visit:
http://www.dot.state.oh.us/Divisions/Operations/Maintenance/SnowandIce/Snow%20and%20Ice%20Best%20Practices/Material%20Application%20Guideline%20(MAG).pdf

Appendix B – Application Rates for Property Management Operations

Rates derived from the Sustainable Salt Initiative[1]			
Pavement Temperature (°F) and Trend (↑↓)	Surface Condition and LOS	Dry Rock Salt (NaCl)	
		Pounds per 1000 ft^2	Pounds per acre
15-20 ↑	The surface has been cleared of snow/ice; Application Rate for Bare Pavement LOS	14	610
15-20 ↓		13.5	588
20-25 ↑		13.25	577
20-25 ↓		12.75	555
25-30 ↑		12.5	545
25-30 ↓		11	479
30 ↑		11	479
>30 ↓		10	436

[1]The Sustainable Salt Initiative (SSI) rates are representative of the average of total rates collected from winter management companies participating in the Snow and Ice Management Association's SSI during 2015-2016 and 2016-2017 winter seasons. For more information and to access "Sexton, Phillip Charles. 2017. Sustainability Analysis of the Commercial Winter Management Industry's Use of Salt. Master's thesis, Harvard Extension School" visit https://dash.harvard.edu/handle/1/33826971